THE SALT INDUSTRY IN OHIO

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INTRODUCTION

The purpose of this paper is to discuss the production of salt and salt products in the state of Ohio. Salt deposits in the state will be described along with possible explanations of their origin. Current methods of mining and brine production will also be covered.

USES OF SALT

Salt or halite, is a mineral of great importance to man. It is used for many things ranging from food seasoning to ice control. Salt is used in the food processing industry as a preservative and for seasoning. The leather industry uses it for tanning hides. Road crews spread it on icy streets to lower the melting point and rid roads of accumulated ice and snow. By far the largest use for salt is in the chemical industry. Approximately 53% of all the salt produced is used in the chemical industry and most of this amount is used in the production of chlorine. Chlorine is produced by electrolysis, which is passing an electrical current through molten salt. The salt decomposes to form metallic sodium and chlorine. Electrolysis of an aqueous solution of salt yields caustic soda and chlorine. Salt is one of the building blocks of the chemical industry and is the most abundant source of Na^+ and Cl^- ions. These ions are used to produce nine other chemicals that are the basis of the chemical industy. These are soda ash, calcium chloride, caustic soda, sodium sulfate, hydrochloric acid, sodium cyanide, and sodium hypochlorite. From these chemicals a myriad of products are produced, ranging from abrasives and ceramics to perfume and plastics. It is easy to see why salt is used in greater quantity and for more applications than any other mineral.

SALT DEPOSITS IN OHIO

Salt deposits in Ohio are contained in the upper Silurian Salina Group. The Salina Group underlies all of Ohio except the southwestern part near Cincinnati. Salt bearing portions of the Salina underlie about 20 counties in the eastern part of the state. They extend about 100 miles from Ashtabula County to Muskingum County. Single salt beds extend for considerable distances and are laterally persistent. The depth to the top of the salt beds is least in Lorain County (1400 feet) and greatest in Monroe County (6600 feet). This indicates a regional dip of ½ to 1 degree southeasterly (see fig. 1). Salt is mined under Lake Erie where the salt beds are nearest the surface (mineable at 1700 to 1900 feet). It is solution mined in Wayne, Summit, and Lake Counties at depths 1500 to 2700 feet. This exploits the thinner beds that would not be feasable to mine (see fig. 4, right hand column under Industrial use).

Map of eastern Ohio and depth to top of salt beds

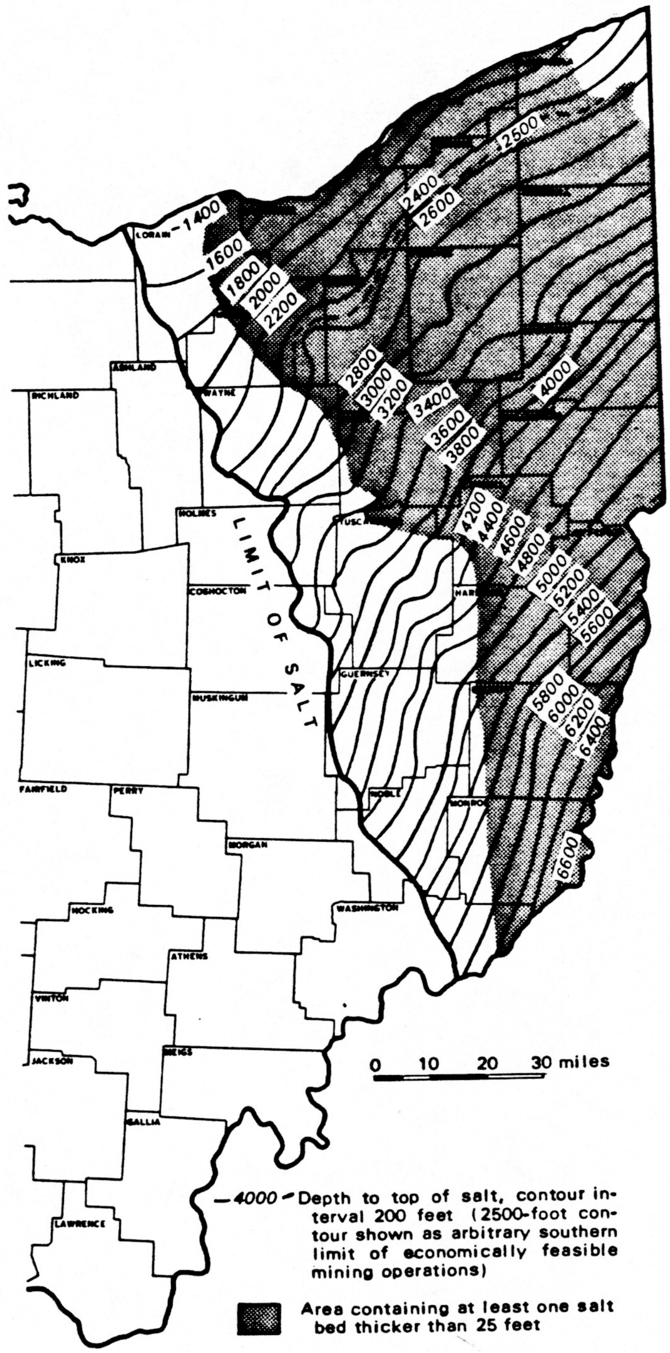

Figure 1.

Source. Clifford, M. J. Silurian Rock Salt of Ohio. 1973.

ORIGINS OF THE SALT DEPOSITS

Origin of the salt beds is unclear. However it appears that the deposits originated from the evaporation of seawater. Evaporation of about 90% of a volume of seawater precipitates salt and other minerals like anhydrite, gypsum, potassium salts and magnesium salts. Only a small amount of salt is produced from a large amount of seawater and it is believed that thick salt beds are the result of many cycles of flooding and evaporation or are precipitated from a density layered system. Deposition of marine halite occurs today in local barred lagoons and in supertidal zones in very arid regions. However, this does not explain the great uniform thickness and lateral extent of the Salina deposits.

Explanation of these salt deposits is attempted by three current models. One is called the Epeiric Sea model. This proposes an epeiric sea with a large gently sloping shelf. The shelf inhibits circulation with the sea. The water becomes more saline as distance from shore decreases giving rise to a sequence of evaporites shown in fig. 2B.

A second model is called the Sabkha model or supratidal model. " This model proposes that halite originates as either a direct precipitate on a flooded sabkha or as a replacement product of preexisting sulfates which were deposited in a sabkha environment." (R.A. Heimlich, Selected Field Trips in Ohio, 1974.) (see fig. 2C).

Models of deposition for Ohio salt deposits

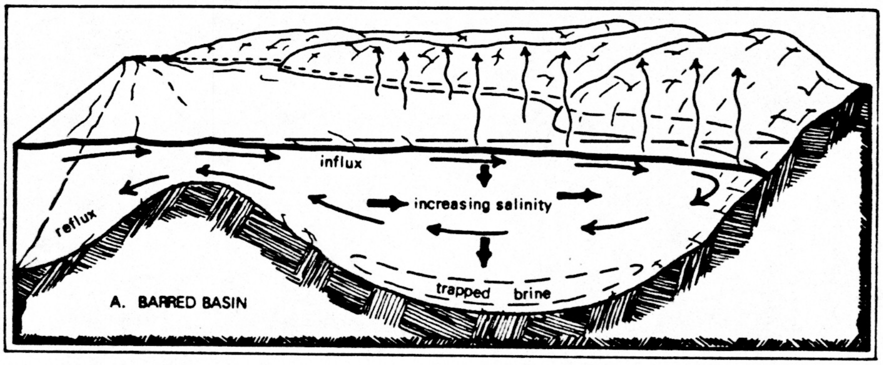

Figure 2A.

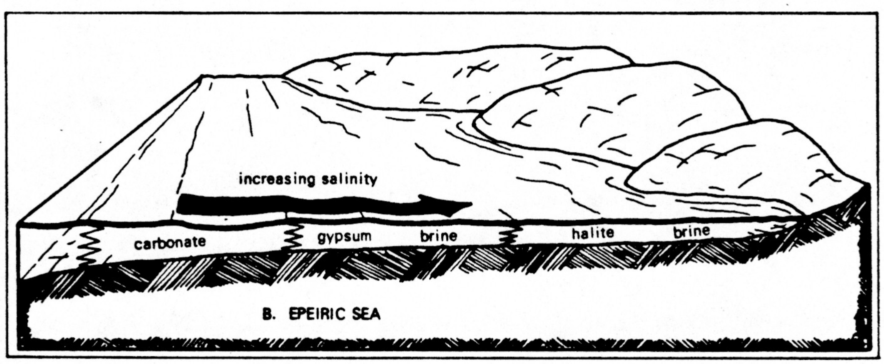

Figure 2B.

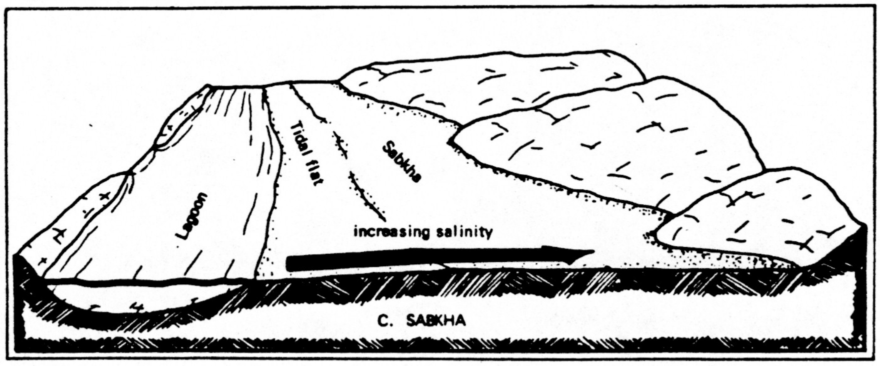

Figure 2C.

Heimlich, R. A. Selected Field Trips in Ohio. 1974.

Evidence for the Sabkha model are features such as desiccation cracks, sulfate nodules, halite crusts, and erosion surfaces. These are characteristic of the sabkha environment. They have been found in the New York Basin but are not characteristic of the Salina.

Most recent explanations of the Salina deposits have used a model called the Barred basin model. This proposes a basin separated from the sea by a barrier that restricts circulation between the sea and the basin. Water evaporates from the basin faster than it enters by rain and runoff and the basin becomes hypersaline. Since salinity and density are directly related, the water in the basin becomes layered with salinity increasing downward. Precipitation occurs in the bottom layers of the basin giving rise to salt beds of varying thicknesses (see fig. 2A). Precipitation continues in this fashion until the basin is filled or the barrier is breached.

EVIDENCE FOR THE BARRED BASIN THEORY

Strong evidence points to the barred basin theory. The layer-cake structure of the Salina implies that the salt beds were deposited in a large basin. A series of transgressions and regressions could account for this structure but the salt beds would contain many unconformities with clastic and fossiliferous beds. These are not present. It is thought that the salt was precipitated from a density layered system as a rain that blanketed large areas. The salt beds also thin over highs of increased thickness of the underlying Lockport Group. Currently, the only theory that uses this mechanism for deposition of this type is the barred basin theory.

PAST SALT PRODUCTION IN OHIO

Early settlers found salt in southeastern Ohio in Mississippian and Pennsylvanian sand outcrops. Brine seeps from these outcrops were collected and salt was being produced by evaporation as early as the late 1700's. Shallow wells were drilled near these seeps and many evaporating furnaces sprang up between Meigs and Columbiana counties. Salt production from this natural brine reached about 70,000 tons per year by 1875.

The discovery of the Salina group in Ontario, Canada in 1866 prompted the production of artificial brine. This is brine that is produced by dissolving beds of salt with water and then pumping the solution back out. This brine is more concentrated than natural brine and requires only 1/4-1/2 as much energy to render the same amount of salt. This method of salt production, which yields a salt of higher purity, gave a boost to Ohio's salt industry.

Surrounding states began producing artificial brine from the Salina and cut into Ohio's salt industry. Production declined to 30,000 tons in 1890 and most evaporation operations were abandoned by this time. More recently, solution mining has undergone some changes for the better. The system of hydraulic fracturing has allowed for increased production and reduced maintenance costs. The overall trend and demand for all types of salt is on the rise.

PRESENT SALT PRODUCTION IN OHIO

Ohio produces 6 million tons of salt annually and is one of the leading salt producers in the country. In 1983 it was fourth behind Texas, Louisiana, and New York. Ohio's contribution (13%), is mined at two underground mines and four artificial brine fields. One underground mine is at Whiskey Island in Cleveland and the other is at Fairport Harbor. The brine fields are located in Akron, Barberton, Rittman, and Painesville. Also, a Meigs county plant still uses natural brine from Mississippian and Pennsylvainian sands, but this accounts for less than (1%) of the states total. Ohio's salt production has risen steadily from 2 1/2 million tons in 1958 to 3 1/2 million tons in 1983 with an estimated value 87 million dollars. The industry employs about 800 people statewide.

Active salt operations in Ohio

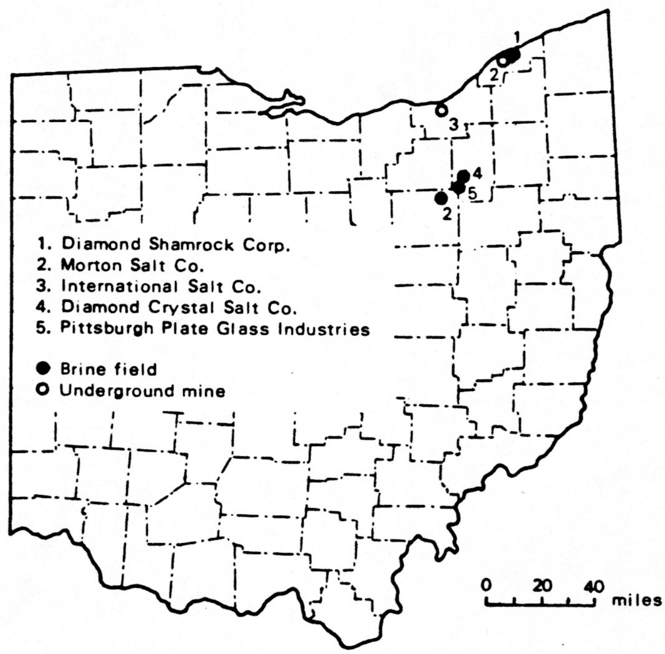

Figure 3.

Source. Heimlich, R. A. Selected Field Trips in Ohio . 1974

SALT MINES

The International Salt Company's mine on Whiskey Island exploits the F_2 salt unit of the Salina group (see strat. section fig. 4). The F_2 unit exceeds 50 feet in thickness at the mine site but it is usually thinner elsewhere. The salt is mined at a depth of 1750 feet. Typical thickness ranges from 18 to 22 feet. The Cleveland mine operates on some 600 acres beneath Lake Erie. The mine extends 1 mile northwesterly from Cleveland where 16 foot diameter shafts service the mine. The salt is mined by the room and pillar method which leaves about 50% of the salt intact for support. These pillars are typically 80 feet on a side. Rooms are 45 feet wide, 20 feet high, and 120 feet long. "At the working face the salt is undercut about 12 feet back and holes are drilled for blasting with ammonium nitrate. After blasting the salt is picked up by end loaders and trucked to primary crushers" (R.A. Heimlich, selected field trips in Ohio, 1974). The salt is then sent on for further crushing, screening and inspection. All operations take place underground. Daily production is about 8,000 tons and mill capacity is about 700 tons per hour.

The Fairport Harbor mine is operated by the Morton Salt Company. Operations take place beneath Headlands State Park and under Lake Erie. The salt bed mined here is the F_1 unit of the Salina Group. It is about 17 feet thick and mined at a depth of 1900 feet. Like the Cleveland mine, the room and

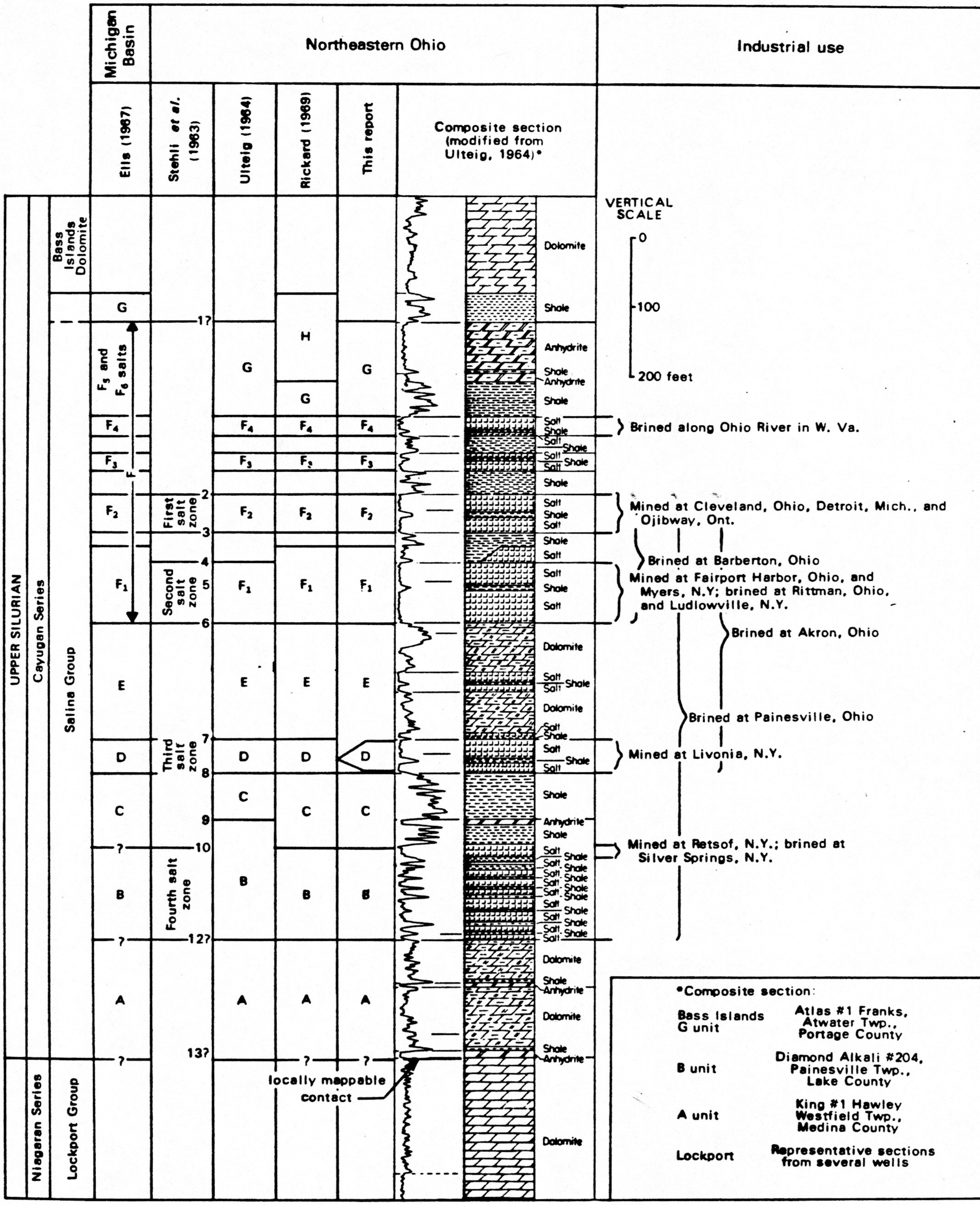

Figure 4. Stratigraphic section of the Salina Group.

Source. M. J. Clifford, Silurian Rock Salt of Ohio. 1973 pillar method is used here. Both mines produce about 3 million tons of salt annually and most of this is used as road salt.

BRINE FIELDS

Ohio's leading brine producer is The Diamond Shamrock corporation in Painesville. It operates 80 wells intermittently. Second is P.P.G. Industries near Barberton with three fields and an unknown number of wells. Two smaller brine producers are Morton Salt in Rittman and Diamond Crystal Salt near Akron. Salt produced from evaporation of these brines is used for table salt, food processing, water softening and chemical manufacturing.

Artificial brine is produced from wells drilled into deep salt beds. After the hole is drilled it is lined with casing and tubing is installed within the casing. Fresh water pumped into the well dissolves enough salt to become saturated. The brine is then pumped back to the surface and sold as brine to the chemical industry or evaporated to produce other salt products.

Early brine wells were simple and introduced water through the casing and pumped the brine out through the tubing. These wells were short lived and not very productive. This type of well setup encouraged salt solution at the top of the cavity because the fresh water (less dense) would rise to the top of the salt bed and dissolve the roof of the cavity. The brine tended to collect at the base of the cavity (more dense) and prevent solution of the bottom of the cavity. The resulting cavity is shaped like an inverted cone, which over a large area could lead to subsidence or collapse (see fig 5A1).

More efficient methods of producing brine have been developed such as the Detroit method or reverse circulation. This method pumps fresh water in through the tubing and brine out through the casing. The tubing is directed at the base of the cavity to promote solution there. Adjustment of the tubing is required to keep it at the bottom of the cavity as solution progresses (see fig. 5A2).

Another method called the Trump method uses a cushion of air or inert fluid such as fuel oil that floats on top of the brine and protects the roof of the cavity from solution. The cushion may be raised or lowered to control the area of the cavity exposed to solution (see figs. 5B1 and 5B2).

After long periods of time nearby wells will often connect. When this happens one well can be used for injection of fresh water and the other for extraction of brine. This arrangement is preferred over the single well because of longer well life and a higher rate of brine flow (see fig. 5B2). Hydraulic

Methods of artificial brine production

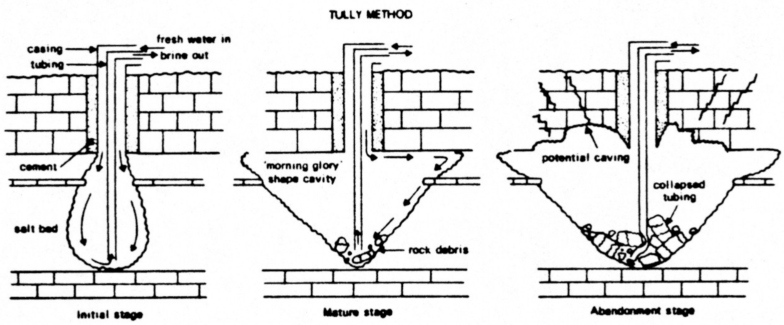

Figure 5A1.

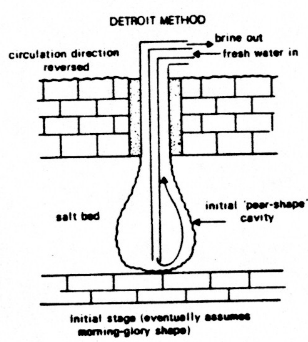

Figure 5A2

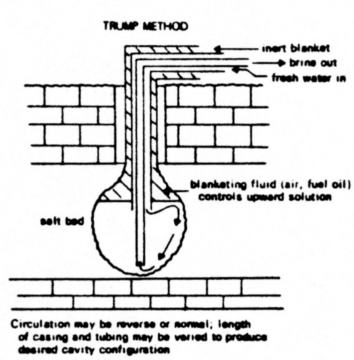

Figure 5B1.

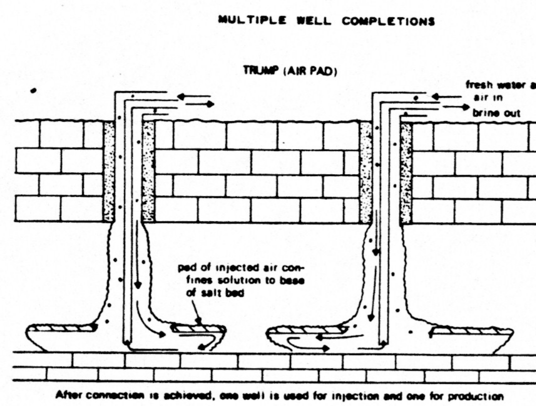

Figure 5B2.

Source. Clifford, M. J. <u>Silurian Rock Salt of Ohio</u>. 1973.

Methods of artificial brine production

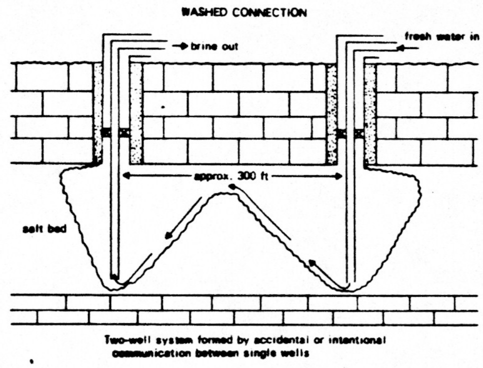

Figure 5C.

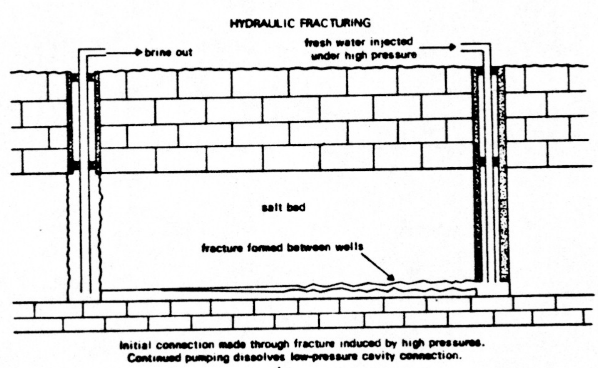

Figure 5D.

Source. Clifford, M. J. Silurian Rock Salt of Ohio. 1973.

fracturing is a method of connecting two wells by a fracture induced by high pressure. Since most solution occurs between the two wells instead of around them there is less danger of collapse and casing or tubing damage due to rock falls (see fig. 5D).

THE SALINA GROUP

The Salina Group is of the Upper Silurian Cayugan Series consisting of interbedded dolomite, shales, anhydrite and halite. Rocks in this group were deposited over a period of about 1 1/2 million years in the area of the Michigan and Appalachian basins. The Salina is underlain by the Lockport Group and overlain by the Bass Island Dolomite. The Salina rocks make up a major stratigraphic interval in parts of Michigan , Ontario, New York, Pennsylvania, Ohio and West Virginia. Salt bearing portions of the Salina underlie about 20 counties in the eastern part of Ohio. The general dip of these beds is 1/3 degree SE in Cuyahoga County and 1 degree SE in Monroe county (see fig. 1).

Before the advent of geophysical logs the Salina salts were believed to be discontinuous and distributed in an erratic fashion. This was because the Salina rocks were difficult to describe in well samples and salts were difficult to recover from these samples. Current evidence shows that the Salina rocks (and salt beds) are persistent and blanket deposits over large areas.

The Salina Group is divided (by Clifford 1973) into units A through G in ascending order, Units B,D,E,F, contain salt. Unit F contains four salt beds, F_1 through F_4. Thicknesses range up to 50 feet and some have been found up to 100 feet. The thickest identified deposit of salt has been 250 feet. The salt in the F_1 unit is mined at Fairport Harbor and the F_2 unit is mined at Cleveland. Other thinner salt beds of this group are solution mined for brine (see fig. 4).

INDUSTRY

PROCESSING

Processing of mined halite is limited to crushing. To produce very fine grades of commercial salt, a recrystallizer is somtimes used. In this process rock salt is dissolved in a high temperature brine. The halite dissolves but impurities such as calcium sulfate do not. The impurities can be separated and the halite precipitates in a pure form. Processing salt for human consumption is usually done by evaporating brine to produce a fine grained clean salt.

TRANSPORT

Transportation of salt or brine from producing location to consumer is done by water, rail, or highway. Highway transport is the most expensive and it is rare to truck salt more than a few hundred miles because the cost of transportation would exceed the value of the salt. Water is by far the cheapest method. Ohio's two salt mines are strategically located on the shores of Lake Erie which gives access to all of the Great Lakes and the east coast through the St. Lawrence Seaway. The Ohio River provides another waterway for bulk transportation of salt to the southren United States and the Gulf of Mexico.

STORAGE AND HANDLING

The chief problems with storage and handling of salt is caking and degradation. Caking of salt can be minimized by the addition of an anti-caking agent such as YPS (yellow prussiate of soda). Caking is not a problem with coarse salt (#3/8 inch or larger) but finer grained salt can be affected by several factors. Among these are transit time, moisture content, method and duration of storage, chemical composition, and temperature. Degradation of salt tends to occur through handling of all types. It should therefore be handled as few times as possible from producer to consumer.

FUTURE OF SALT

Through scientific advancement new uses for salt have been found. Among these are the use of brine for preparation and compaction of the subsurface of highways and parking lots. It can be used to control dust in coal mines and is starting to be used to increase the solubility of certain chemical solvents. With these new uses for salt and salt products and its increasing use in industry the demand for salt is on the rise.

Another future consideration for the salt industry is the by-product of the mine. The cavities left after mining have been studied for possible storage sites of such things as liquid hydrocarbons, toxic wastes, radioactive wastes, and even geothermal energy. Some abandoned salt cavities are already being used for such storage.

SUMMARY

Ohio is blessed with an abundance of salt. Most of the salt beds can be reached by brine wells and the thicker mineable beds are fairly close to the surface (about 1800). This makes Ohio a leading salt producing state. Since there is no natural or man-made substitute for salt and the demand for salt products is increasing, the future of Ohio's salt industry looks very promising.

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